

The Effect of Vegetation Increase on the Morphology and Dynamics of the Israeli Coastal Dunes

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Introduction

The southeastern Mediterranean coastal dunes, formed about 1000 years ago (Tsoar, 1990b), experienced intensive human impact until the second half of the 20th century. As a result, natural vegetation could not grow and flourish therefore, active barchan and transverse dunes were formed (Fig. 1A). Since the 1950s, however, a sporadic recovery of the vegetation brought about a change in the morphology and dynamics of the sand dunes.

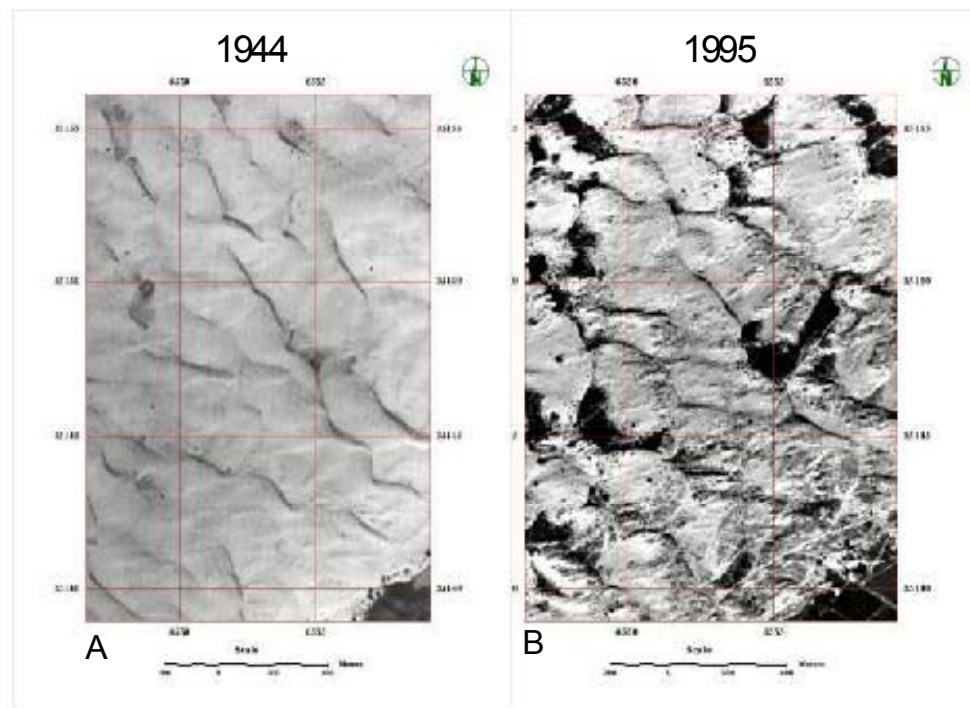


Figure 1. Aerial photographs of part of the research area south of Ashdod. A. 1944. B. 1995

The aim of this study is to monitor the effect of vegetation recovery on the morphology and dynamics of the coastal sand dunes. Research was carried out in the Ashdod – Nizzanim Sand Park. The average annual rainfall in the research area is 500 mm and the average relative

deviation is 29%. The rainy season starts in October and ends in May. Winter and spring are the only seasons with strong winds above the threshold of sand transport in the southeastern Mediterranean, mostly coming from the SW - W. In summer the wind is milder and originates as a sea breeze from the NW that is much more consistent than those of the winter and spring storms. Fig. 2 shows the sand rose of the DP values. The research area is categorized as a low-energy wind environment (Fryberger, 1979), which usually fosters vegetated sand dunes (Tsoar & Illenberger, 1998).

Methods

Aerial photographs were analyzed for 12 dates from 1944, 1956, 1959, 1960, 1966, 1970,

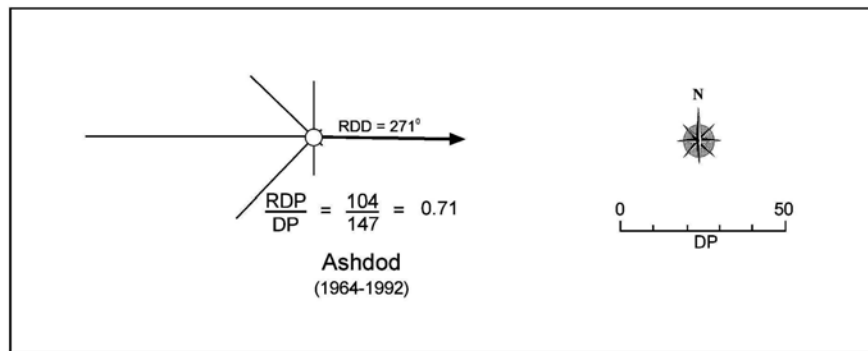


Figure 2. Sand Rose and DP – RDP data from the research area

1974, 1980, 1985, 1986, 1990, and 1995. The oldest available aerial photographs of the area were taken in 1917 and 1918. There is no observable change in the dunes and vegetation cover between 1917 and 1944. Therefore, the 1944 photograph that was used in this work represents the dune and vegetation conditions during the first half of the 20th century and probably prior to that time as well.

The analysis of these aerial photographs was done digitally, using geographic information technologies in which all of the photographs were brought into one geographic framework. All of the images were geocoded into a UTM projection using the WGS 1984 ellipsoid description of Earth. This projection resulted in metric coordinates that were easy to use for quantitative analysis. Overall, the resulting images had a ground resolution of 1 to 2 meters per pixel.

Vegetation is easily discerned in the aerial photographs. The change in the amount of area with vegetation cover was measured by looking at the brightness value of the pixels in a 560 acre area that appeared in three aerial photographs. The rate of advance for 15 dunes that were identified in all of the aerial photographs was found by determining the advance of the brink line. This was done by averaging the distance of 15 perpendicular lines drawn between every pair of brink lines. Some of the brink lines change during this period from crescent shapes opening into the downwind direction (typical to barchan\transverse dunes), to crescents opening into the upwind direction (typical to parabolic dunes).

Results and Discussion

In 1944, the dunes were of transverse/barchan type with no vegetation cover (Fig. 1A). The stable interdune areas were used for agriculture. As a result of the cessation of agricultural and grazing land-use, vegetation started to recover, first in the interdune areas (the agricultural plots) during the 1950s and then on the dune crests during the 1960s. There were few changes in the 1970s, mainly in the appearance of some parabolic forms, though slip-faces were distinct. Vegetation sprang up rapidly during the 1980s and even more so in the early 1990s, covering the slip-faces and changing the form of the transverse dunes into parabolic forms (Fig. 1B).

Results show an increase in vegetation cover from 4.3% in 1944 (most of it in the agricultural plots in the interdunes areas) to 8.4% in 1974 and to 17% in 1995 (most of it on the crest and lee sides of the dunes). The average rate of advance of the 15 dunes is shown in Fig. 3. There was a discernible decrease in the rate of advance except during 1966-1974. It is assumed that the decrease between 1956-1966, 1974-1980 and 1980-1990 is due to the increase in vegetation cover. The decrease in the rate of advance occurred simultaneously with the gradual process of transformation of barchan and transverse dunes into parabolic dunes.

Since the limiting factor for vegetation on dune sand is wind erosion (Tsoar, 1990a),

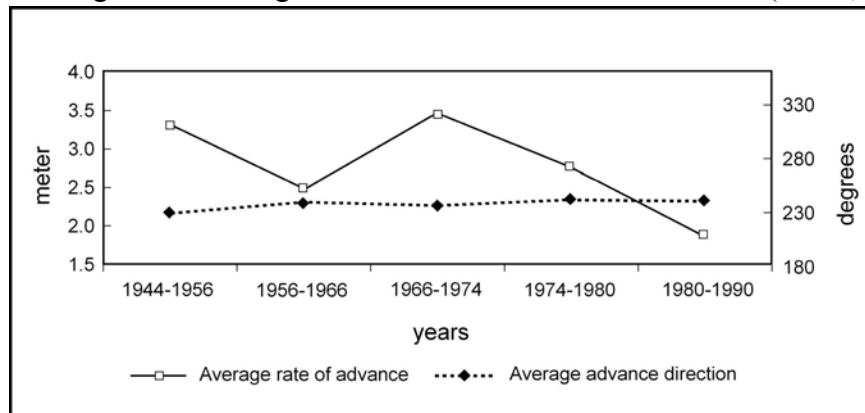


Figure 3. The average rate of advance and advance direction for 15 dunes.

vegetation would be able to germinate and sprout on those areas of the dune that have little or no erosion. According to the profile of barchan or transverse dunes, erosion on the windward slope of the dune diminishes gradually toward the crest, which is an area of neither erosion nor deposition (Fig. 4). Hence, vegetation recovers on the barchan and transverse dune crests only (Fig. 5), which starts the process of transforming these dunes into parabolic ones. The dynamics of the transverse and barchan dunes is modified once vegetation is established on the crest. Some of the sand eroded on the windward slope will be trapped by the vegetation on the crest and will create several nebkhas there. The consequent reduction in the amount of sand deposited on the slip face will cause vegetation to establish itself there as well. Only the eroded windward slope will be devoid of vegetation (Fig. 5).

The continuous erosion will change the windward slope profile from convex to concave. The now parabolic dune will advance by erosion of sand on the windward slope, which is trapped by vegetation on the crest and the lee slope. The strong bed scour on the upper windward slope undercuts the shrubs, exposes their roots and destroys the plants. Hence, the parabolic dune advances by undermining the frontal row of vegetation on the crest that is facing the wind. Shrubs located downwind trap the sand eroded by this process.

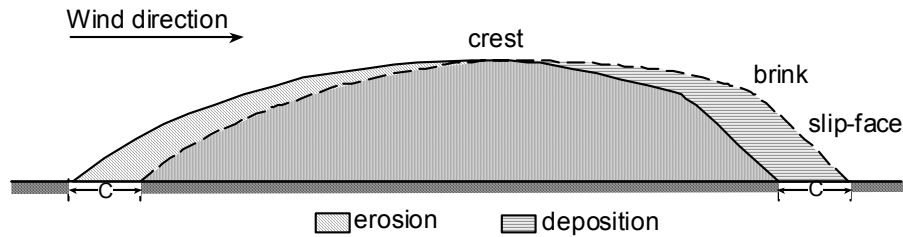


Figure 4. Profiles of a barchan dune (before and after) advance at the rate of c . Note that the crest is the only area with neither erosion nor deposition.

This mechanism of advance is different from the one described in the literature for parabolic dunes (Livingstone & Warren, 1996), which refers to the anchoring of the trailing arms by vegetation and the relatively high forward advance of the central apex.



Figure 5. The coastal dunes in 1995. Note the vegetated crest and the bare windward slope

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